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THE USE OF FERTILIZERS IN CALIFORNIA.

The fortieth anniversary of the admission of California into the Union reminds us that she has ceased to be a stripling. With this advance in dignity comes the inference that however fertile her soils, it is to be expected that those long occupied or heavily cropped will now require serious care in order to keep up or restore production. That this is really so is proved by the rapidly increasing correspondence on the subject that is addressed to this station; and to avoid the unnecessary rehearsal of general statements in each individual case, it seems desirable to put in print for general information what can be stated in a general way on this subject. Of course many individual cases will still require special consideration on account of peculiar conditions of soil or location; for in a great many instances the failure to produce satisfactory crops is not at all due to soil exhaustion, but to improper physical conditions of the subsoils, unsuitable cultivation or irrigation, alkali, etc. The fact that orchards and vineyards form costly investments of much greater permanence than the annual crops that occupy the vast majority of the cultivated land east of the Rocky mountains, and the high returns so often realized from them, has brought the manure question forward here much earlier than has usually been the case in the United States; and happily the silly adage that "manuring is too costly and will never pay," which has long kept agriculture on the down grade elsewhere, has never had a serious foothold in California. The sovereign truth that nothing pays worse than poor crops upon large areas of which the cultivation costs just as much as if it were yielding high returns, is quite generally appreciated here. Cultivating too much land poorly, and getting poor returns both as to quantity and quality, has been the bane of farmers all over the East, and has doubtless done at least as much toward "agricultural depression" as all other causes combined.

But whether fertilization will pay or not clearly depends directly upon the particular requirements of each soil. Unlike Europe, where long cropping has reduced all soils alike to a condition when they require an "all-around" fertilizer, the soils of California have mostly had only a *one-sided wear* from the constant succession of one and the same crop. In orchards and vineyards this state of things is unavoidable, since they are expected to last 20 to 40 years without renewal and possibility of rotation of crops. It is this one-sided wear, inseparable from the chief horticultural industries of the State, that requires special attention at this time; for it is clear that to apply "complete" fertilizers in these cases, would be to pay out a portion of their cost uselessly, since nothing can be gained by adding to the soil more of the ingredients that are already abundantly present in an available form.

In order to fertilize intelligently we must know, first of all, what ingredients are chiefly drawn upon by the crop sold off the land;

secondly, we must know which of these ingredients are so abundantly present in the soil (or irrigation water, as the case may be) to render their replacement unnecessary for the present at least.

The subjoined table* gives some insight into the amounts removed from the soil by some of the chief fruit crops, of nitrogen, potash, phosphoric acid and lime; these being, according to all experience, the only ones of which the replacement need ordinarily be considered in fertilization. These amounts are expressed both with reference to 1000 pounds of fresh fruit, and to what, according to our best information, may be assumed to be a "fair crop" per acre. The latter figure is, of course, liable to great variations and differences of opinion; but by the aid of a little arithmetic each one can calculate for himself the data suitable to his own case or views. The crop assumed in the case of oranges is 325 boxes per acre of 15-year-old trees; that of grapes is intended to represent a mean between upland and lowlands.

QUANTITIES OF SOIL INGREDIENTS WITHDRAWN BY VARIOUS FRUIT CROPS.

Fresh Fruit.	Total ash, lbs.	Potash, lbs.	Phos-acid, lbs.	Nitro-gen, lbs.
GRAPES, 1000 lbs.....	3.8	5.0	1.52	1.70
Crop of 10,000 lbs. per acre.....		50.0	15.20	17.00
ORANGES (seedless), 1000 lbs.....	6.07	2.78	.67	2.69
Crop of 20,000 lbs. per acre		55 60	13.40	53.80
PEARS, 1000 lbs.....	3.3	1.8	.5	.6
Crop of 20,000 lbs. per acre.....		36.-	10.-	12.-
PLUMS, 1000 lbs.....	2.9	1.72	.44	4.2
Crop of 30,000 lbs. per acre.....		51.60	13.20	167.7
APPLES, 1000 lbs.....	2.2	.80	.03	.6
Crop of 20,000 lbs. per acre.....		16.00	6.00	12.0

It will be seen that for equal weights of these fruits, *grapes* take from the soil by far the largest amount of mineral matter, of which nearly five-ninths is potash; they also carry off the largest amount of phosphoric acid. For seedless grapes the latter item, would, however, be considerably smaller.

Next in the drain of total mineral matter from the soil stands the *orange;* it also draws heavily on the potash, and also upon the nitrogen of the soil, but less than the grape upon phosphoric acid. This independently of the seeds, the analysis having been referred to seedless fruit; seed-bearing (seedling) fruit would draw more heavily both on phosphoric acid and nitrogen.

Pears come next as regards total mineral matter, but draw quite lightly on nitrogen.

Plums (including prunes) are conspicuous chiefly for their heavy draught on the nitrogen of the soil, greatly exceeding in that respect the orange for equal weights, and enormously for an (assumed) average crop.

The difference between *apples* and *pears* in respect to soil exhaustion for an equal weight of fruit is quite striking, the amount of potash in apples being less than half; the phosphoric acid only a trifle over half as much as in the pear; while nitrogen is equal in both and quite low as compared to the orange, which has over four times as much and must therefore be accounted relatively much more nourishing to man, as well as more exhausting to the soil.

While the data given above in relation to the "outgo" of soil ingredients through the harvesting of the several fruits may be considered as holding good, practically, in all countries and on all soils, the vast differences in the nature and composition of *different soils* introduce an element of uncertainty as to the need of returning to every soil the full amount of the outgoing ingredients. Few soils are about evenly constituted with respect to the four important plant-food substances; there is in most cases one or several of these present in superabundance, so that to replace the small amount carried off by the crop would be as useless as "carrying coals to Newcastle," at least for the present. *The analysis of soils and irrigation waters is necessary to gain information on these points.*

As regards waters, the information so obtained is positive and unimpeachable. Whatever is dissolved in the irrigation water is absolutely available to vegetation, and the amount annually so conveyed to the soil is capable of close calculation on the basis of the current practice of each irrigation district. If the amount of any substance so given to the soil approximates to, or exceeds the amount withdrawn by crops, it is quite certain that no money needs be expended in the purchase of that particular substance as a fertilizer.

As regards soils, the indications given by chemical analysis are not so definite, because the acids used in the laboratory are more powerful than those at the command of the roots of plants; although some of the latter (*e. g.* oxalic acid, that of sorrel, rhubarb, etc.) approximate closely to the same solvent power. Here experience must be our main guide; and this has shown that practically, soils containing (by the results of analysis) more than a certain percentage of a given substance, may be considered as abundantly supplied with the same; while if the percentage so indicated falls below a certain other point, such ingredient may be considered as being deficient. The crucial test in either case is the experimental use of that substance as a fertilizer on the soil in question; when if it fails to produce a definite favorable result it may beconsidered that the native supply is sufficient, and *vice versa.*

It is obvious that in order to secure to the farmer this saving of the purchase of superfluous fertilizing ingredients, a comprehensive system of investigation of soils and waters is necessary. This has been from the outset the central thread of the work of this station; the object being to obtain as quickly as possible the facts necessary for the compilation of a soil map of the State. For want of funds for field work, and too limited a force for the laboratory work, this fundamental plan has been carried out only to a limited extent and chiefly in certain regions where considerable interest in agricultural improvement was manifested. We are not, therefore, as yet, prepared to give information as to the entire State; and unless some special provision is made, it will be long before this can be the case. But so far as the work has gone, the following points may be considered as practically settled:

1. From climatic as well as geological causes, nearly all the soils of the State may be considered as abundantly supplied with *lime.* The chief exceptions occur in the higher por-

*The ANALYSES of ashes here given are mostly those of European chemists, generally accepted as representing averages. California-grown fruits will be investigated at this Station the coming season for this purpose.

tions of the foothills, where the rainfall is high and summer rains occur. In *all* the valley soils lime is abundant; and liming is therefore not among the means of improvement usually to be thought of in California. This applies to the use of quick-lime and ground limestone; not necessarily to the use of marls, which usually contain other ingredients besides lime to render their use valuable where it can be done with little cost.

2. Almost the same that is stated above of lime, may be said of *potash*. The great majority of soils in this State, more especially nearly all valley soils, and absolutely *all* soils in which there is the least manifestation of alkali, contain an abundance of available potash for all agricultural purposes; so much so that dissolved potash salts frequently circulate in the soil water. Most irrigation waters furnish an additional supply, sometimes enough of itself to make up for all that crops take away. Outside of the rainy belts of the Sierra and of the Northwest Coast, therefore, the addition of potash in fertilization must in general be considered in the light of "carrying coals to Newcastle"—superfluous and unprofitable at the present time; and farmers should object to paying for the potash in commercial fertilizers (put there under the Eastern idea of making a "complete" fertilizer), because the investment will pay them no interest. They should demand for their money the ingredients that will pay them for their use in this State, regardless of what may pay elsewhere.

The few cases in which at present the use of potash *will* pay, are those of intense culture in vegetable gardens and berry patches, where crops are grown continuously and successively throughout the season. Here the draft upon the soil ingredients is so heavy that within a few years *all* require current replacement.

3. Of *phosphoric acid*, an ingredient so important that even in Europe it is beginning to be claimed as the practical measure of fertility, analysis has shown an almost universal *scarcity* in the soils of this State; always excepting the alkali soils, in which it, or its compounds, frequently circulate in proportionally large amounts. Phosphoric acid is one of the substances to be first suspected of exhaustion in the non-alkaline soils of California; it is therefore an ingredient that should be prominent in *all* compound commercial fertilizers, and which will be found to "pay" in most cases of decreasing production.

4. As to the fourth of the critical soil and plant ingredients, *nitrogen*, its ordinary measure in soils is the vegetable mold or humus, the presence of which is generally manifested, and outside of "red" soils is fairly measured, by the more or less blackish tint when wetted. From climatic causes, humus is rarely abundant in the upland soils of the State, and very generally its amounts may be said to be small. This is especially true of the mesa soils of the South —those best adapted to the growth of the citrus fruits—and hence it is reasonable to suppose that *a lack of nitrogen* will be among the first things to be apprehended when that fruit shrinks in size, and production falls, on these soils.

Elsewhere stable manure is the ordinary source of this as well as of the other substances when required only in moderate amounts; but for many reasons stable manure is less available in the dry climate of California than elsewhere. It is produced only in small quantity in horticultural communities; and when put in the soil it is long in decaying and becoming effective. It should for our climates be systematically "cured" in the manure-pile before being used—a point of vantage which explains, in part, the good effects of sheep-corral manure.

By far the most convenient, and at present certainly the cheapest and most available source of nitrogen at command of the farmer is *Chile saltpeter*, which contains about 16 per cent of nitrogen, in its most effective form. From 150 to 200 pounds per acre is the usual dose; more than this will not be used by the crop plants in one season, and a surplus is likely to be washed out of the soil by the winter rains. Moreover, an excessive application might result in too much wood and too little fruit, and that fruit of a sappy, flavorless character, though of large size.

Sulphate of ammonia is the other most available source of nitrogen obtainable in commerce; a good commercial article contains 20 per cent and over, of nitrogen. It does not, however, act quite as rapidly as the Chile saltpeter.

To the citrus-growers, then, who at present appear to be most concerned about the fertilizer question, I would say that, well-cured stable and sheep-corral manure apart, their best resort at present is to the commercial phosphates and superphosphates of high and honest grade, mixed, either by themselves or by the manufacturer, with a proper proportion of Chile saltpeter or ammonia sulphate; and generally no potash whatever.

In order to cover approximately the ground of the questions most commonly propounded in our correspondence on the subject of fertilizers, the following points are briefly stated:

This station has no direct or definite knowledge of the quality or "trueness to name" of any of the commercial fertilizers now sold in this State. Analyses of mere samples sent by the manufacturers or others prove little or nothing, so long as no regular "fertilizer control" is established by State authority. That this should be done as soon as possible, in the interest both of the users and honest manufacturers of fertilizers, is manifest; and nearly all the older States have found this regulation of the fertilizer trade necessary long ago. At present this station declines to analyze and certify to the composition of fertilizer samples, except in cases of suspected fraud; for the reason that such samples prove nothing as to the general quality of the material put on the market, and their analyses have been used in advertising as though offering a kind of guarantee or recommendation on the part of the director. The latter disclaims pointedly any such responsibility and does not authorize the use of his name in connection with any fertilizer advertised. He has, however, no reason to question the *bona fide* character of the several fertilizers manufactured in this State. That in individual cases disappointment must often occur, is natural from the causes stated above and proves nothing against the honest composition of the goods. In this as in other cases, the right thing may be put in the wrong place. The useless addition of considerable potash is the objection lying against several of the brands in the market.

Farmers should be willing to pay a good price for a high-grade fertilizer, especially in the case of superphosphates. The only consequence of insisting on too low a price is that

the manufacturer, in self-defense, adds to the active matters enough of some cheap, inert material to be able to afford the lower rate; the result being that the farmer pays freight, to say the least, on "dirt" which he might as well put in himself on the spot, if so inclined. "Spent refinery charcoal" in coarse grain is about as unprofitable an investment as a farmer can well make; he should be willing to pay enough to justify the manufacturer in reducing every grain of it to the soluble form by the use of enough sulphuric acid. It is not advisable for any one to attempt to do this at home.

In regard to the use of *bones*, it may be said that any one may with little trouble use all the bones accumulating about a homestead in either of three ways:

1. Bones put into a *well-kept* (moistened) *manure-pile* will themselves gradually decay and disappear, enriching the manure to that extent.

2. Raw bones may be bodily *buried in the soil* around the trees; if placed at a sufficient depth, beyond the reach of the summer's heat and drought, the rootlets will cluster around each piece and in the course of a few years consume it entirely. But it will not do to have these root-clusters broken up by cultivation every season.

3. Bones may be packed in moist wood ashes, best mixed with a little quicklime; the mass kept moist but never dripping. In a few months the hardest bones will be reduced to a fine mush, which is as effectual as superphosphate. "Concentrated lye" and soil may be used instead of ashes. In this process the *nitrogen* of the bones is lost, going off in the form of ammonia, the odor of which is very perceptible in the tank used.

For neither of these processes should the bones be *burnt*. The burning of bones is an unqualified detriment to their effectiveness, which can only be undone by the use of sulphuric acid.

4. Bones *steamed* for three or four hours in a boiler under a pressure of 35 to 50 pounds, can, after drying, be readily crushed in an ordinary barley-crushing mill, and thus be rendered more convenient for use. Practically very little of the nitrogen (glue) of the bones need be thus lost.

Very good *bone-meal* is found in the market at reasonable rates.

For information concerning the value and proper uses of *land plaster* or *gypsum* (also one of the inquiries continually made), I refer to pages 144 and 145 of the "*Report on the Experiment Stations*," lately issued, which will be mailed free to any one desiring it. It may here simply be stated that while gypsum is not a general fertilizer like the phosphates and nitrates, for the simple reason that it does not contain, and therefore cannot supply, the plant-food substances of which the withdrawal by crops causes sterility; yet its uses, especially in the irrigated regions and on alkali soil, are so many and so important, that it should be very widely used so soon as a reasonably cheap supply can be obtained.

Berkeley, Oct. 6. E. W. HILGARD.